(12) EUROPEAN PATENT SPECIFICATION

(54) A stress wave load cell.

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Description

The present invention relates to load cells and in particular to load cells which are responsive to structure borne stress waves.

Common forms of load cell use strain to cause a change of electrical resistance or to generate electrical signals by the piezo-electric effect. Such devices are susceptible to electromagnetic interference, and are affected to various degrees by high temperatures and vibrations.

The present invention seeks to provide a novel stress wave load cell.

Accordingly the present invention provides a stress wave load cell comprising a propagation member which allows the propagation of stress waves therethrough, at least one transducer acoustically coupled to the propagation member, at least one damping member arranged such that when a load is applied to the load cell a damping load is applied on at least one surface of the propagation member by the damping member, the damping load applied by the damping member increases with the load, the at least one transducer being arranged to launch a stress wave signal into the propagation member and at least one means to detect the stress wave signal after it has propagated through the propagation member and been damped by any damping load applied by the damping member on the propagation member, the at least one means to detect the stress wave signal being arranged to convert any detected stress waves into an electrical signal, a processor being arranged to process the electrical signal to give an electrical output signal as a measure of the load applied on the load cell.

A single transducer may launch the stress wave signal into the propagation member and the transducer is the at least one means to detect the stress wave signal after it has propagated through the propagation member.

A first transducer may launch the stress wave signal into the propagation member and a second transducer is the at least one means to detect the stress wave signal after it has propagated through the propagation member.

The propagation member may be formed from metal, glass or ceramic.

The propagation member may have a first surface, a second surface parallel to the first surface, a first damping member arranged to apply a damping load on the first surface and a second damping member arranged to apply a damping load on the second surface.

The damping member may be formed from rubber.

The at least one transducer may be acoustically coupled to the propagation member by a waveguide.

The electrical output signal may operate a switch when a predetermined load is detected.

The electrical output signal may operate an alarm when a predetermined load is detected.

Load transmission members may act on the first and second damping members such as to cause the first and second damping members to apply a damping load on the propagation member.

The present invention will be more fully described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a cross-sectional view of a stress wave load cell according to the present invention.

Figure 2 is a cross-sectional view of a second embodiment of a stress wave load cell according to the present invention.

Figure 3 is a view in the direction of arrow A in Figure 2.

Figure 4 is a perspective view of a third embodiment of a stress wave load cell according to the present invention.

Figure 5 is a graph of decay rate of the stress waves against load.

A stress wave load cell 10 according to the present invention is shown in Figure 1. The stress wave load cell 10 comprises a propagation member 12, which may be a sheet or bar or other suitable member, formed from a material which allows the propagation of stress waves therethrough. The propagation member conducts stress waves and may for example be formed from metal, glass or ceramic. A first damping member 14 and a second damping member 16 are arranged in close proximity to opposite surfaces of the propagation member 12. The damping members 14 and 16 are resilient and are formed from a rubber. A first load transmission member 18 and a second load transmission member 20 are arranged to act on the first and second damping members 14 and 16 such that the damping members 14 and 16 move into damping contact, and/or apply a greater damping effect on the propagation member 12 when a load is applied to the load cell 10. First and second acoustic emission type transducer 22 and 24 are acoustically coupled to the propagation member 12. The first transducer 22 is a transmitter and is electrically connected to a pulse generator (not shown). The second transducer 24 is a receiver and is electrically connected to a signal processor (not shown). The signal processor may be connected to either a recorder or a display, or to both if desired.

In operation of the stress wave load cell 10 the application of a compressive load onto the load transmission members 18 and 20 causes the first and second damping member 14 and 16 to move into damping contact with the propagation member 12, (if the damping members are not already in contact with the propagation member 12) and as the load applied to the load cell increases the damping applied by the damping members 14 and 16 upon the propagation

member 12 increases. The pulse generator (not shown) sends electrical pulses to the first transducer 22, which converts the electrical pulses into stress waves which are launched into the propagation member 12. The second transducer 24 detects the stress waves after they have propagated through the propagation member 12 and converts the stress waves into electrical signals. The electrical signals corresponding to the stress waves detected are processed by the processor to give an electrical output signal which is a measure of the load applied on the load cell 10. The decay rate of a reverberative or diffuse, stress wave field set up in the propagation member is dependent upon the load applied on the load cell 10. Thus the processor may be arranged to measure the decay rate of the reverberative stress wave field, and this measure is indicative of the amount of damping applied by the damping members 14 and 16 and hence the load applied on the load cell 10.

Figure 5 shows a graph of stress wave decay rate against the load applied on the load cell, and a straight line is achieved which indicates that the relationship between applied load and stress wave decay rate is linear.

In the example above, stress waves with a frequency content in the region of 150 KHz were used, although other suitable frequencies of stress waves may be used. The transducers used were resonant piezoelectric transducers.

In Figures 2 and 3 a stress wave load cell 30 is shown which is substantially the same as the embodiment in Figure 1, and operates in a similar manner, but differs in that a waveguide 26 is acoustically coupled between the propagation member 12 and a single transducer 28. The transducer 28 acts both as a transmitter and as a receiver, and is electrically connected to pulse generator, a processor, a recorder and display.

The embodiment in Figures 2 and 3 allows the load to be measured at one location, while the transducer is located at a remote position and is acoustically coupled to the propagation member by a waveguide of suitable length. The waveguide is formed form a material which also allows stress waves to propagate therethrough.

The stress wave load cell 40 in Figure 4 is substantially the same as the embodiment in Figure 1, and operates in a similar manner, but does not have the load transmission members. This arrangement allows a single object, or a plurality of objects to be placed on the damping member 14 at a plurality of locations and the load cell 40 measures the load applied by each of the objects and gives an integrated measure of the load applied on the load cell.

The present invention allows a load cell to be produced which is less susceptible to electrical interference, and the embodiment in Figures 2 and 3 may be used in corrosive, high temperature or other hostile environments by using the remote transducer. The stress wave load cell is an active system and failures may be easily detected.

The stress wave load cell may be used as a touch sensitive switch, an intruder detector or a device to detect removal of an object all of which detect changes in load. In the use of the stress wave load cell as an intruder detector, the stress wave load cell may be positioned under a carpet.

Claims

1. A stress wave load cell comprising a propagation member (12) which allows the propagation of stress waves therethrough, at least one means (24) acoustically coupled to the propagation member (12) to detect stress waves, the at least one means (24) to detect the stress waves is arranged to convert any detected stress waves into an electrical signal, a processor is arranged to process the electrical signal to give an electrical output signal as a measure of the load applied on the load cell, characterised in that at least one damping member (14,16) is arranged such that when a load is applied to the load cell a damping load is applied on at least one surface of the propagation member (12) by the damping member (14,16), the damping load applied by the damping member (14,16) increases with the load, at least one transducer (22) is arranged to launch a stress wave signal into the propagation member (12) and the at least one means (24) to detect the stress wave is arranged to detect the stress wave signal after it has propagated through the propagation member (12) and has been damped by any damping load applied by the damping member (14,16) on the propagation member (12).

2. A stress wave load cell as claimed in claim 1 in which a single transducer (28) launches the stress wave signal into the propagation member (12) and the transducer (28) is the at least one means to detect the stress wave signal after it has propagated through the propagation member.

3. A stress wave load cell as claimed in claim 1 in which a first transducer (22) launches the stress wave signal into the propagation member (12) and a second transducer (24) is the at least one means to detect the stress wave signal after it has propagated through the propagation member (12).

4. A stress wave load cell as claimed in claim 1, claim 2 or claim 3 in which the propagation member (12) is formed from metal, glass or ceramic.

5. A stress wave load cell as claimed in any of claims 1 to 4 in which the propagation member (12) has a first surface and a second surface parallel to the first surface, a first damping member (14) is arranged to apply a damping load on the first surface and a second damping member (16) is arranged to apply a damping load on the second surface.

6. A stress wave load cell as claimed in any of claims 1 to 5 in which the damping member (14,16) is formed from rubber.

7. A stress wave load cell as claimed in any of claims 1 to 6 in which the at least one transducer (28) is acoustically coupled to the propagation member by a waveguide (26).

8. A stress wave load cell as claimed in any of claims 1 to 7 in which the electrical output signal operates a switch when a predetermined load is detected.

9. A stress wave load cell as claimed in any of claims 1 to 8 in which the electrical output signal operates an alarm when a predetermined load is detected.

10. A stress wave load cell as claimed in claim 5 in which load transmission members (18,20) act on the first and second damping members (14,16) such as to cause the first and second damping members (14,16) to apply a damping load on the propagation member (12).

Patentansprüche

1. Druckwellen-Kraftmeßzelle mit einem Ausbreitungsglied (12), welches Druckwellen hindurchtreten läßt, mit wenigstens einer Einrichtung (24), die akustisch mit dem Ausbreitungsglied (12) gekoppelt ist, um Druckwellen festzustellen, wobei die wenigstens eine Einrichtung (24) zur Feststellung der Druckwellen derart angeordnet ist, daß irgendwelche festgestellten Druckwellen in ein elektrisches Signal umgewandelt werden, und wobei ein Prozessor vorgesehen ist, um die elektrischen Signale zu verarbeiten und ein elektrisches Ausgangssignal als Maß für die auf die Kraftmeßzelle ausgeübte Belastung zu liefern, dadurch gekennzeichnet, daß wenigstens ein Dämpfungsglied (14, 16) derart angeordnet ist, daß dann, wenn eine Kraft auf die Kraftmeßzelle ausgeübt wird, eine Dämpfungsbelastung auf wenigstens eine Oberfläche des Ausbreitungsgliedes (12) durch das Dämpfungsglied (14, 16) ausgeübt wird, wobei die Dämpfungsbelastung, die durch das Dämpfungsglied (14, 16) ausgeübt wird, sich mit der Belastung erhöht, und wenigstens ein Wandler (22) angeordnet ist, um ein Druckwellensignal in das Ausbreitungsglied (12) zu schicken, und die wenigstens eine Einrichtung (24) zur Feststellung der Druckwelle so angeordnet ist, daß das Druckwellensignal festgestellt wird, nachdem dies über das Ausbreitungsglied (12) ausgebreitet und durch irgendeine Dämpfungslast gedämpft wurde, die durch das Dämpfungsglied (14, 16) auf das Ausbreitungsglied (12) ausgeübt wurde.

2. Druckwellen-Kraftmeßzelle nach Anspruch 1, bei welcher ein einziger Wandler (28) das Druckwellensignal in das Ausbreitungsglied (12) schickt und der Wandler (28) die wenigstens eine Vorrichtung zur Feststellung des Druckwellensignals bildet, nachdem

dieses durch das Ausbreitungsglied ausgebreitet wurde.

3. Druckwellen-Kraftmeßzelle nach Anspruch 1, bei welcher ein erster Wandler (22) das Druckwellensignal in das Ausbreitungsglied (12) schickt und ein zweiter Wandler (24) die wenigstens eine Einrichtung darstellt, um das Druckwellensignal festzustellen, nachdem dieses durch das Ausbreitungsglied (12) ausgebreitet wurde.

4. Druckwellen-Kraftmeßzelle nach Anspruch 1, Anspruch 2 oder Anspruch 3, bei welcher das Ausbreitungsglied (12) aus Metall, Glas oder Keramikmaterial besteht.

5. Druckwellen-Kraftmeßzelle nach einem der Ansprüche 1 bis 4, bei welcher das Ausbreitungsglied (12) eine erste Oberfläche und eine zweite, hierzu parallele Oberfläche aufweist und ein erstes Dämpfungsglied (14) eine Dämpfungskraft auf die erste Oberfläche und ein zweites Dämpfungsglied (16) eine Dämpfungskraft auf die zweite Oberfläche ausübt.

6. Druckwellen-Kraftmeßzelle nach einem der Ansprüche 1 bis 5, bei welcher das Dämpfungsglied (14, 16) aus Gummi besteht.

7. Druckwellen-Kraftmeßzelle nach einem der Ansprüche 1 bis 6, bei welcher der wenigstens eine Wandler (28) akustisch mit dem Ausbreitungsglied durch einen Wellenleiter (26) gekoppelt ist.

8. Druckwellen-Kraftmeßzelle nach einem der Ansprüche 1 bis 7, bei welcher das elektrische Ausgangssignal einen Schalter betätigt, wenn eine vorbestimmte Belastung festgestellt wird.

9. Druckwellen-Kraftmeßzelle nach einem der Ansprüche 1 bis 8, bei welcher das elektrische Ausgangssignal einen Alarm betätigt, wenn eine vorbestimmte Last festgestellt wird.

10. Druckwellen-Kraftmeßdzelle nach Anspruch 5, bei welcher Lastübertragungsglieder (18, 20) auf das erste und zweite Dämpfungsglied (14, 16) in der Weise einwirken, daß das erste und zweite Dämpfungsglied (14, 16) eine Dämpfungskraft auf das Ausbreitungsglied (12) ausüben.

Revendications

1. Boîte dynamométrique pour ondes de contrainte comprenant un élément (12) de propagation qui permet à des ondes de contrainte de se propager dedans, au moins des moyens (24) coulés acoustiquement à l'élément (12) de propagation pour détecter des ondes de contrainte, les moyens (24) pour détecter les ondes de contrainte étant disposés pour convertir toute onde de contrainte détectée en un signal électrique, un appareil de traitement étant disposé pour traiter le signal électrique afin de donner un signal électrique de sortie représentatif de l'effon appliqué sur la boîte dynamométrique, caractérisée en ce qu'au moins un élément (14, 16) d'amortisse-

ment est disposé de sorte que, quand un effort est appliqué sur la boîte dynanométrique, un effort d'amortissement est appliqué sur au moins une surface de l'élément (12) de propagation par l'élément (14, 16) d'amortissement, l'effort d'amortissement appliqué par l'élément (14,16) d'amortissement augmentant avec l'effort, au moins un transducteur (22) étant disposé pour émettre un signal d'ondes de contrainte à l'intérieur de l'élément (12) de propagation et les moyens (24) pour détecter l'onde de contrainte étant disposés pour détecter le signal d'ondes de contrainte après qu'il se soit propagé au travers de l'élément (12) de propagation et qu'il ait été amorti par tout effort d'amortissement appliqué par l'élément (14, 15) d'amortissement sur l'élément (12) de propagation.

2. Boîte dynamométrique pour ondes de contrainte selon la revendication 1, dans laquelle un unique transducteur (28) émet le signal d'ondes de contrainte à l'intérieur de l'élément (12) de propagation, le transducteur étant constitué des moyens pour détecter le signal d'ondes de contrainte après qu'il se soit propagé au travers de l'élément de propagation.

3. Boîte dynamométrique pour ondes de contrainte selon la revendication 1, dans laquelle un premier transducteur (22) émet le signal d'ondes de contrainte à l'intérieur de l'élément (12) de propabation, un second transducteur (24) étant constitué des moyens pour détecter le signal d'ondes de contrainte après qu'il se soit propagé au travers de l'élément (12) de propabation.

4. Boite dynamométrique pour ondes de contrainte selon la revendication 1 ou la revendication 2 ou la revendication 3, dans laquelle l'élément (12) de propagation est constitué de métal, de verre ou de céramique.

5. Boîte dynamonétrique pour ondes de contrainte selon l'une quelconque des revendications 1 à 4, dans laquelle l'élément (12) de propabation présente une première surface et une seconde surface parallèle à la première surface, un premier élément (14) d'amortissement est disposé afin d'appliquer un effort d'amortissement sur la première surface et un second élément (16) d'amortissement est disposé pour appliquer un effon d'amortissement sur la seconde surface.

6. Boîte dynamométrique pour ondes de contrainte selon l'une quelconque des revendications 1 à 5, dans laquelle l'élément (14, 16) d'amortissement est constitué de caoutchouc.

7. Boîte dynamométrique pour ondes de contrainte selon l'une quelconque des revendications 1 à 6, dans laquelle le transducteur (28) est couplé acoustiquement à l'élément de propagation au moyen d'un guide d'ondes (26).

8. Boîte dynamométrique pour ondes de contrainte selon l'une quelconque des revendications 1 à 7, dans laquelle le signal électrique de sortie actionne un commutateur lorsqu'un effort prédéterminé est détecté.

9. Boîte dynamométrique pour ondes de contrainte selon l'une quelconque des revendications 1 à 8, dans laquelle le signal électrique de sortie actionne une alarme lorsqu'un effort prédéterminé est détecté.

10. Boîte dynamométrique pour ondes de contrainte selon la revendication 5, dans laquelle des éléments (18, 20) de transmission de l'effort agissent sur les premier et second éléments (14, 16) d'amortissement de façon à amener les premier et second éléments (14, 16) d'amortissement à appliquer un effort d'amortissement sur l'élément (12) de propagation.

Fig.1.

LOAD

10

18

24

14

22

12
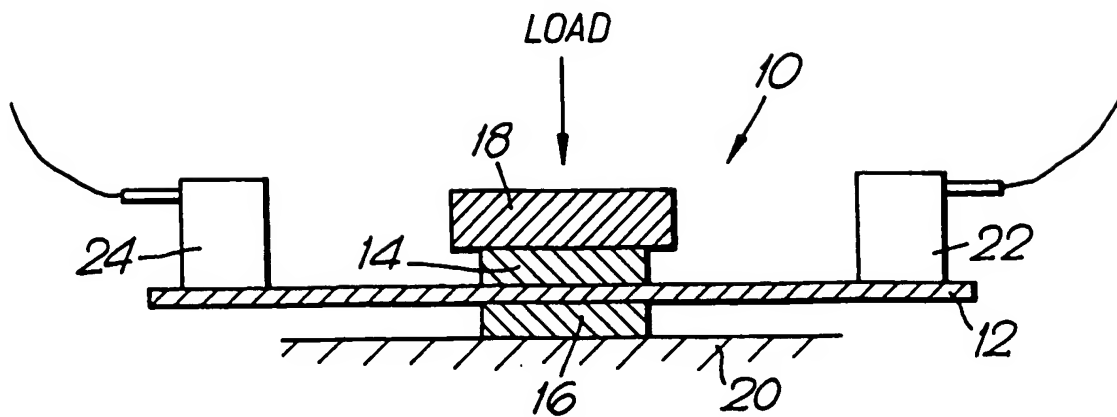
16

20

Fig. 2.

LOAD

14

18

30

12

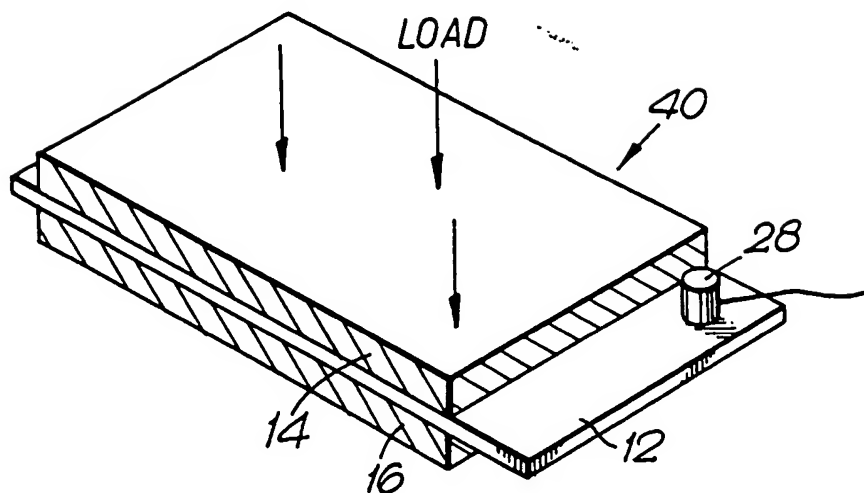A

28

26

16

20

Fig. 3.

12

18

26

28

Fig.4.

LOAD

40

28

14

16

12
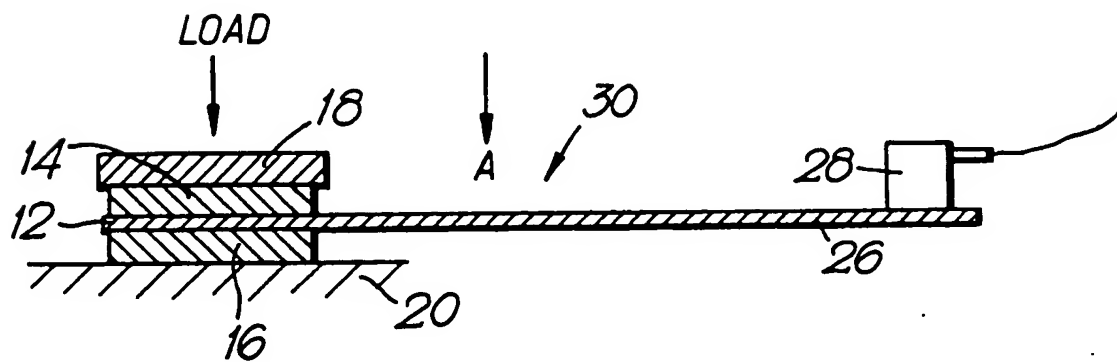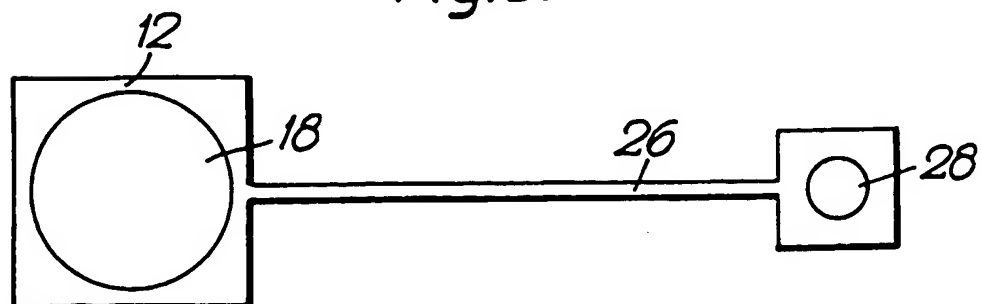
Fig.5.

LOAD CELL MEASUREMENTS